



Factors Affecting Household–Level Climate Change Mitigation: A Study in Medan, Indonesia

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Article details:

Published: 30th June 2025



Abstract

Climate change mitigation in households refers to activities undertaken by households to lower greenhouse gas emissions and slow down climate change. As the fourth biggest and most densely populated city in Indonesia, Medan has the tendency to emit more greenhouse gases, which contributes to global warming and accelerates climate change. Therefore, mitigation practices are crucial, starting from the household level. The objective of

this study is to identify the factors affecting household-level climate change mitigation in Medan. This cross-sectional study was conducted in seven subdistricts of Medan, involving 270 households selected through purposive sampling. Data analysis was performed using linear regression tests. Study findings indicate that the number of household members ($B = 0.317$ (95% CI: 0.082 to 0.552); $p = 0.008$), house floor area ($B = -0.473$ (95% CI: -0.771 to -0.552); $p = 0.002$), household income ($B = 0.666$ (95% CI: 0.450 to 0.881); $p < 0.001$), and head of household's education level ($B = 0.642$ (95% CI: 0.402 to 0.881); $p < 0.001$) significantly affect climate change mitigation in households. Household income is the strongest predictor of household-level climate change mitigation in Medan ($p < 0.001$). It is recommended that the Medan city government establish household-based climate change mitigation programs, particularly targeting middle-income households, focusing on providing clean energy subsidies, promoting eco-friendly behavior, and improving household energy efficiency.

Keywords: Climate change mitigation, Household, Income

To cite this article :

Fadila Oktaviani Lubis, Nurmaini Nurmaini, E. N. (2025). Factors Affecting Household–Level Climate Change Mitigation: A Study in Medan, Indonesia. *International Journal of Health, Education and Social (IJHES)*, 8(6), 51–65.



Introduction

Climate change is a global issue marked by rising average earth temperatures along with increased intensity and frequency of extreme weather events worldwide (IPCC, 2023). According to the United Nations Environment Programme (2022), climate change is caused by growing levels of greenhouse gases (GHGs) accumulated in the atmosphere, particularly carbon dioxide (CO₂), emitted by human activities. Carbon dioxide is the dominant gas contributing to global warming, accounting for up to 77% of total GHG emissions equivalent to carbon dioxide (CO₂e) across the world (Tanveer & Purnima, 2019). Indonesia is reported to be among the ten largest CO₂ emitters in the world, reaching nearly 700 million tons of carbon dioxide (Mt CO₂) per year (IEA, 2022). In 2022, GHG emissions emitted in Indonesia were estimated at 1.24 gigatons equivalent to carbon dioxide (Gt CO₂e), or around 2.3% of total global greenhouse gas emissions. The household sector adds to CO₂ emissions in Indonesia, accounting for 3.8% of direct CO₂ emissions and 20.7% of indirect CO₂ emissions (IESR, 2021).

Every day, household activities that require energy-consuming appliances, especially electrical devices, such as lighting, air conditioning, refrigerators, televisions, computers, washing machines, irons, or other electronic devices, along with the use of fuel for transportation and cooking, as well as agricultural and livestock activities, have contributed to the escalation of GHG emissions in the atmosphere, which is further impacted by the increasing population, activities, and community lifestyles (Sasmita et al., 2018). As population density grows, so does energy consumption and the amount of carbon emissions emitted. The carbon footprint (the total amount of GHG emissions emitted from activities) of households, calculated based on the number of households per unit of residential building area, tends to result in higher carbon emissions in high-density compared to low-density residential areas (Latifa et al., 2022). Furthermore, a study explains that, aside from housing (45.32%), transportation (20.45%) and food production and consumption (19.62%) are the main contributors to household carbon footprints (Sun et al., 2021).

Family characteristics appear to affect differences in household carbon emissions. A previous study observed differences in carbon emissions between households in different regions



with varying income levels. The higher the family income, it was found that carbon emissions per capita also tended to increase (Lai et al., 2020). Family income is also associated with greenhouse gas emissions, particularly in the household waste sector (Purba et al., 2024). Additionally, the number of household members, household tenure status, and household head's gender, age, and education level are other determinants reported as contributing to differences in carbon footprints across households (Zen et al., 2022).

Climate change is predicted to cause changes in temperature and increase the intensity of extreme rainfall in Indonesia, leading to risks of disasters such as floods and droughts that can adversely affect public health (Bappenas, 2019). Climate change-induced increases in rainfall and humidity also drive the reproduction and prolong the survival of mosquitoes. Consequently, the risk of transmission of diseases such as malaria, dengue fever, chikungunya, and other mosquito-borne diseases becomes greater. Meanwhile, indirectly, climate change also enlarges the potential for crop failure and reduces agricultural production, which can cause difficulties in ensuring adequate nutrition for the community (Sumampouw, 2019). This emphasizes the importance of mitigation efforts to slowing down climate change.

Climate change mitigation refers to actions taken to slow down climate change through the reduction of GHG emissions or the enhancement of GHG absorption from various emission sources. Households can participate in climate change mitigation through various strategies, such as using LED lights and energy-efficient or energy-saving household appliances, limiting the use of air conditioners, and utilizing public transportation (Hung et al., 2023; Olatunde et al., 2024). Managing waste through the principles of reuse, reduce, and recycle is also among the efforts to mitigate climate change at the household level, thereby reducing GHG emissions generated from the increasing volume of waste (Subekti & Sukaryo, 2022).

As the fourth biggest city in Indonesia, with around 2,460,858 residents and a population density of 9,283 people per square kilometer (BPS, 2022), Medan has the tendency to emit more greenhouse gases, which contribute to global warming and accelerate climate change, necessitating mitigation actions starting at the household level. However, preliminary survey results from 30



households in Medan indicate that climate change mitigation at the household level is still low, as shown by the following activities: frequent use of air conditioners (66.6%), lack of energy-efficient appliances such as LED lights or energy-efficient household devices (83.4%), excessive electricity consumption (76.6%), reliance on private vehicles as the primary mode of transportation (83.3%), improper waste management through burning (13.3%), lack of waste recycling (93.3%), continued use of single-use plastics (83.3%), and lack of reusable shopping bags (63.3%). Therefore, this study aims to identify the factors affecting climate change mitigation among households in Medan.

Methods

This is an observational analytical study with a cross-sectional design conducted in Medan from December 2024 to June 2025. The sample size was determined using Isaac and Michael's table based on the population size (523,097 households) in Medan with a 10% margin of error, resulting in a sample of 270 households. The sample was obtained from seven subdistricts, that is, 30% of the total subdistrict population to represent the 21 subdistricts in Medan (Asenahabi & Ikoha, 2023). The sample taken from each subdistrict was divided proportionally from the total sample and selected using purposive sampling. The inclusion criteria are respondents who have been residing in Medan for more than a year, are married and aged over 21 years, living in households with at least three members and with access to electricity and private transportation, while the exclusion criteria are households engaged in business, trade, agriculture, or livestock farming activities at home.

The dependent variable in this study is climate change mitigation, and the independent variables are household characteristics, which include the floor area of the house, number of household members, head of household's education level, and household income. These variables were measured through interviews using a questionnaire. The collected data were then analyzed univariately to describe the frequency distribution of households based on their characteristics and climate change mitigation practices. Meanwhile, bivariate analysis aims to examine the association between each independent variable and the dependent variable using simple linear regression tests,



followed by multivariate analysis to determine the independent variables that have the most significant effect on the dependent variable using multiple linear regression tests.

Results

Based on data collected from 270 households in Medan, the results of the study are as follows.

Table 1. Household Characteristics and Household-Level Climate Change Mitigation in Medan

	n (=270)	% (=100)
Household characteristics		
House floor area		
$\leq 36 \text{ m}^2$	15	5.6
37–60 m^2	119	44.0
61–120 m^2	72	26.7
$> 120 \text{ m}^2$	64	23.7
House type		
Permanent	261	96.7
Semi-permanent	9	3.3
Number of floors		
One floor	171	63.3
Two floors	97	36.0
Three floors	2	0.7
Number of rooms		
One room	2	0.7
Two rooms	67	24.8
Three rooms	115	42.6
Four rooms	82	30.4
Five rooms	4	1.5
Number of household members		
Mean $\pm$ standard deviation (SD)		4.27 $\pm$ 1.072
Minimum, maximum		3, 9
Head of household's level of education		
High school	115	42.6
Diploma	30	11.1
Bachelor's degree	112	41.5
Master's degree	13	4.8
Household income		
Below the minimum wage ($\leq$ IDR 4,000,000)	93	34.4
Above the minimum wage		



IDR 4,000,001–IDR 8,000,000	89	33.0
IDR 8,000,001–IDR 12,000,000	52	19.3
IDR 12,000,001–IDR 16,000,000	26	9.6
>IDR 16,000,000	10	3.7
Household-level climate change mitigation		
Mean ± SD		9.57 ± 2.124
Minimum, maximum		6, 15
Category		
Low	91	33.7
Moderate	127	47.0
High	52	19.3

Table 1 above shows that most households in Medan have a house floor area of 37–60 m² (44.0%), permanent houses (96.7%), one-floor houses (63.3%), and three-room houses (42.6%). The mean number of household members per household in Medan is four people, with the minimum number being three people and the maximum being nine people. Most of the heads of households in Medan have a high school education (42.6%) and a bachelor's degree (41.5%). Based on income, the majority of households have an income below IDR 4,000,000, or below the minimum wage (34.4%), and above the minimum wage in the range of IDR 4,000,001–IDR 8,000,000 (33.0%) per month. The findings also reveal that the mean climate change mitigation score for households is 9.57, with the highest score being 6 and the lowest 15. By category, most climate change mitigation among households in Medan is classified as moderate (47.0%), followed by those in the low category (33.7%). Only 19.3% of households engage in high levels of climate change mitigation.

Table 2. Results of Bivariate Analysis

Variable	B	95% CI		p	R	R square
		Lower	Upper			
Number of household members	0.317	0.082	0.552	0.008	0.160	0.026
House floor area	−0.473	−0.771	−0.175	0.002	0.187	0.035
Household income	0.666	0.450	0.881	<0.001	0.348	0.121
Head of household's education level	0.642	0.402	0.881	<0.001	0.307	0.094



Bivariate analysis results, as shown in Table 2 above, indicate that the number of household members has a significant effect on climate change mitigation in households, with a positive association ($B = 0.317$; $p = 0.008$), suggesting that adding one household member increases the score of climate change mitigation by 0.317 units. However, the strength of the association is weak ($R = 0.160$), and this variable can only explain 2.6% of the total variation in household climate change mitigation scores. The findings also show that there is a negative and significant effect of house floor area on climate change mitigation in households, indicating that every 1 m² addition to house floor area decreases the climate change mitigation score by 0.473 units ($B = -0.473$; $p = 0.002$), but the strength of the association is also weak ($R = 0.187$), and this variable can only explain 3.5% of the total variation in household climate change mitigation scores.

Household income also has a significant and positive effect on climate change mitigation in households. Based on the analysis results, every additional IDR 1 in household income per month will increase the score of climate change mitigation in households by 0.666 units ($B = 0.666$; $p = <0.001$). The strength of the association is moderate ($R = 0.348$), and the household income variable can only explain 12.1% of the total variation in household climate change mitigation scores. Head of household's education level also shows a significant effect on climate change mitigation in households, with a positive association indicating that a one-unit increase in head of household education level results in a 0.642-unit increase in climate change mitigation scores. The strength of the association is moderate ($R = 0.307$), and this variable explains only 9.4% of the total variation in climate change mitigation scores in households.

Table 3. Results of Multivariate Analysis

Table 3: Results of Multivariate Analysis						
Variable	B	95% CI		p	R	R square
		Lower	Upper			
Step 1						
Number of household members	0.485	0.261	0.709	<0.001	0.460	0.212
House floor area	−0.603	−0.894	−0.311	<0.001		
Household income	0.539	0.248	0.829	<0.001		
Head of household's education level	0.201	−0.125	0.527	0.225		
Constant	7.444	5.994	8.894	<0.001		



Step 2

Number of household members	0.470	0.247	0.693	<0.001		
House floor area	-0.645	-0.928	-0.361	<0.001	0.455	0.207
Household income	0.666	0.461	0.871	<0.001		
Constant	7.976	6.808	9.143	<0.001		

Based on the results of multivariate analysis, it was found that household income is the strongest predictor of household-level climate change mitigation, with a positive association indicating that each additional IDR 1 of household income increases the score for climate change mitigation by 0.666 units ($B = 0.666$; $p = <0.001$). The R-squared value of 0.207 suggests that the variables of the number of household members, house floor area, and household income can explain 20.7% of the total variation in household climate change mitigation scores, while the remaining 79.3% is influenced by other factors not included in the variables studied.

Discussion

The study findings suggest that the number of household members has a significant effect on climate change mitigation in households, with a positive association indicating that as the number of household members increases, so does the level of climate change mitigation. This is consistent with previous research by Ivanova & Büchs (2022), which reported that adding one household member can reduce per capita carbon footprint by 6%. Interventions aimed at increasing the number of household members can be highly effective in reducing housing-related energy consumption. Family members who live together are likely to share electrical devices and household appliances, cook together, and use air conditioners or heaters together. This action can lower per capita energy use, thereby reducing emissions. Sharing resources within the household not only promotes broader resource conservation (energy, materials, living space, and opportunities to reduce waste) but also strengthens important social foundations and fosters cooperation, care, and responsibility, leading to collective awareness of mitigation practices among family members.

Yang et al. (2025) also found in their study that the per capita carbon footprint related to housing for households consisting of two, three, four, five, and six (or more) members was 53%,



41%, 32%, 26%, and 20% of the carbon footprint of a single-person household, indicating that when the number of household members exceeds two, shared consumption behaviors (e.g., heating, cooling, lighting, and transportation) among household members will drive economies of scale, i.e., a reduction in per capita emissions due to the sharing of resources within the household. Larger households generally tend to have greater efficiency in resource utilization due to the numerous activities carried out collectively, enabling shared responsibilities and collaboration in mitigation practices such as waste management, electricity savings, and the use of energy-efficient appliances (Fowlie & Meeks, 2021).

House floor area is also a factor that affects climate change mitigation in households, but the results of this study show that larger house floor areas actually lower mitigation scores. Huebner & Shipworth (2017) suggest that dwelling size ($r = 0.49$; $p < 0.001$) has a significantly greater effect on household energy consumption than the number of household members ($r = 0.34$; $p < 0.001$). Building size is positively correlated with the number of energy-consuming appliances, meaning that larger houses tend to require more energy for lighting, cooling, and household appliances, thereby hindering mitigation. Having a smaller home can limit the number of items that can be practically stored and used within it, resulting in reduced energy use, which can contribute to lowering carbon emissions. Smaller floor areas also minimize embedded emissions from carbon-intensive building materials such as concrete and steel (Creutzig et al., 2021).

The results of this study also showed that there was a significant effect of the head of household's education level on climate change mitigation in households. The higher the head of household's education level, the greater the tendency towards climate change mitigation. This is aligned with the study by Ogallo et al. (2022), which found that households with low-educated heads of household are more vulnerable to the impacts of climate change due to limited access to information and knowledge about climate variability and change, as well as the adaptation strategies needed to address the challenges arising from climate change. Research findings by Ifejirika et al. (2024) also suggest that education levels are positively correlated with mitigation behaviors, including the use of energy-efficient appliances, switching off lights and devices when



unused, and saving water ($p < 0.05$). It highlights education as a fundamental human resource in motivating households to take action and achieve the capacity needed to adapt and mitigate the adverse impacts of climate change. Communities with higher levels of formal education tend to have access to various sources of information and are more likely to understand complex environmental issues such as climate change, have greater concern and behavioral commitment toward environmental protection, and thus actively participate in climate change mitigation.

Another study conducted by Hoekstra et al. (2024) found that education is negatively associated with climate change skepticism and distrust of climate science, implying that compared to more educated individuals, those with lower levels of education tend to be less concerned about climate change and less trusting of climate science. Educational attainment has also been identified as a significant factor influencing household participation in community-based mitigation programs. Higher-educated communities demonstrate a better understanding of climate change risks and are more likely to take proactive steps, ranging from energy efficiency practices to reducing plastic waste. Furthermore, Okafor et al. (2024) also discovered in their research that education is a significant determining factor in the implementation of climate change adaptation and mitigation strategies such as irrigation, soil conservation, and tree planting.

Based on the findings of this study, it is determined that household income is the strongest predictor of household-level climate change mitigation. As household income increases, so does the tendency to practice mitigation in the household. In a study by Long et al. (2024) in Japan, it was found that high-income households produce higher greenhouse gas emissions but also have a higher capacity to adopt newly developed emission mitigation technologies such as roof solar photovoltaics (PVs) or new energy vehicles (NEVs), which include various types of vehicles using alternative energy sources besides fossil fuels, compared to low-income households. González-Hernández et al. (2019) also showed in their study that mitigation actions and adaptation levels to climate change increase along with income. Households are more likely to engage in mitigation actions if it is within their financial reach and there is sufficient funding to facilitate the



implementation of such actions. Conversely, low income increases vulnerability to the ability to adapt to climate change and mitigation behavior (Ehsan et al., 2022).

Research by Hertwich et al. (2020) similarly found that although high-income households consume more energy, they also have a greater capacity to compensate for carbon emissions and invest in eco-friendly practices. Income is important in expanding access to various eco-friendly products and technologies, such as energy-efficient household appliances, electric vehicles, and efficient housing infrastructure. However, the effect of income is highly dependent on the values and consumption preferences of each household, or in other words, high income does not directly guarantee sustainable climate mitigation behavior and thus must be balanced with good environmental awareness (Zaidi, 2023).

Lastly, some limitations in this study are as follows. The cross-sectional approach is unable to evaluate the dynamics of mitigation behavior at a single time point, thereby weakening the observed effect in concluding a causal relationship. Researchers also were unable to completely control for external factors or confounders that could potentially influence the observed effects. Additionally, reliance on self-reported data collected from respondents may introduce potential biases.

Conclusion and Recommendation

Factors that significantly affect climate change mitigation in households are the number of household members, house floor area, household income, and the head of household's education level. Household income is the strongest predictor of household-level climate change mitigation. The Medan city government is recommended to establish a household-based climate change mitigation program, particularly targeting middle-income households, as they have significant potential to contribute to reducing emissions. Interventions can focus on providing clean energy subsidies, promoting eco-friendly behavior, and managing household energy consumption. Heads of households are also expected to engage all family members in climate change mitigation practices such as reducing energy consumption, using public transportation or selecting eco-



friendly transportation, and managing household waste. Finally, further research is necessary to analyze other contributing factors and their impact on climate change mitigation behaviors within households.



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